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ROLE OF CEPHALOMEDULLARY NAILING IN IPSILATERAL NECK AND SHAFT FRACTURES OF FEMUR

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MADURAI.

CERTIFICATE

This is to certify that the dissertation entitled **"ROLE OF CEPHALOMEDULLARY NAILING IN IPSILATERAL NECK AND SHAFT FRACTURES OF FEMUR"** is a bonafide record of work done by ***Dr. K. G. ASHOK SUNIL GAVASKAR*** in the Department of Orthopaedics, Government Rajaji Hospital, Madurai Medical College, Madurai, under the direct guidance of ***DR.V.RAVIRAMAN M.S.ORTHO., D.ORTHO.,*** & overall guidance of me.

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INTRODUCTION

Ipsilateral neck fractures occur in as many as 9% of all shaft fractures. This injury pattern was first described by Delaney & Street[9] in 1953. In most instances, the neck fracture line is almost vertical and undisplaced or minimally displaced. The femoral neck fracture often is missed[11].

Numerous treatment protocols have been recommended for the treatment of this combination injury pattern. Treatment options include [2,3,5]: (1) Antegrade femoral nailing of the shaft with cancellous screws placed anterior to the nail for fixation of the neck (2) Reconstruction-type intramedullary nailing using proximal interlocking screws that pass through the proximal nail segment, across the femoral neck fracture and into the femoral head (this technique has been described with and without the use of additional cancellous lag screws to augment the neck fixation (3) various plate combinations (including a hip screw and long side plate configuration, a hip screw with short side plate for the neck and separate plate for the shaft, or cancellous screws for femoral neck and a plate for the shaft, and (4) retrograde intramedullary nailing for shaft fixation with cancellous lag screws placed superior to the tip of the nail for neck stabilization. All these techniques have produced varying degrees of success, with the occurrence of femoral shaft nonunions ranging from 2% to 10%[6] and complications involving the femoral neck reported as high as 25%[6]. Consistent recommendations for the treatment of these complications have not been forthcoming.

AIM

The purpose of this study is to analyze the efficacy of cephalomedullary nailing in the treatment of ipsilateral fractures of neck and shaft of femur with special emphasis on technical difficulties and complications

MECHANISM OF INJURY

Fractures of the ipsilateral neck & shaft of femur are usually a result of high energy trauma. Motor vehicle accidents account for nearly 80% of these injuries in various series. Fall from height also contribute a major proportion. These injuries are most common in young and active patients and are usually a component in the polytrauma spectrum[17]. These patients are also likely to have visceral injuries in addition to other skeletal injuries.

The most common mode of violence in producing a fracture of neck and shaft of femur in a motor vehicle accident is **longitudinal or axial compression in an extended and abducted lower limb [27].**

SCHATZKER & BARRINGTON

SIGNS & SYMPTOMS:

Fracture of the femoral shaft or other systemic injuries usually mask the symptoms suggesting a femoral neck fracture. This is the main reason behind the neck fracture being missed in more than 30%[4,7,8] of the cases in many series. Patients with this combination of fractures usually have hemodynamic instability and resuscitating the patient takes precedence. Ipsilateral knee injuries are common and should be looked for, especially ligamentous injuries. Clinical diagnosis of the neck fracture is often not possible calling for a detailed radiological evaluation.

RADIOLOGICAL EVALUATION:

Plain x rays are the initial step in evaluation and often are the only investigation required for diagnostic conformation. Plain x rays of the femoral shaft in two planes {AP and LATERAL} should always be combined with a x ray AP view of the pelvis in all cases of fracture shaft so as not to miss a fracture of the femoral neck. Still many neck fractures are missed in the initial radiographs because most often they are undisplaced[12]. Several neck fractures are diagnosed only during the nailing procedure after they get displaced[19]. Bone scan or Computerized tomography may diagnose an undisplaced fracture of the neck[34] but their routine use in evaluation of these injuries is not necessary.

25% - 30% of femoral neck fractures are missed in initial x rays
10% of these fractures are discovered during or after nailing[9]

Delaney & Street, 1953

Role of CT in diagnosis of occult femoral neck fractures
Eight of fourteen femoral neck fractures associated with fracture of the shaft were missed in the X rays and were subsequently discovered by pre operative CT[34]

Yang et al, 1998

CLASSIFICATION:

We used the AO system of classification in our series. **Type B fractures of the proximal femur were included in our study**. Femoral diaphyseal fractures in our series were either **simple or wedge fractures** according to the AO classification.

Swiontkowski et al classified complex femoral fractures into four types [28]

Type 1) Fracture of the shaft with neck

Type 2) Fracture of the shaft with trochanteric fracture

Type 3) Fracture of the shaft with sub trochanteric fracture

Type 4) Segmental fractures of the femoral shaft

Swiontkowski et al, 1984

Our study group included types 1 and 2 in the Swiontkowski classification.

AO Classification of neck fractures

31- B1	Neck fracture, subcapital, with slight displacement
32- B2	Neck fracture, transcervical
33- B3	Neck fracture, subcapital, non-impacted, displaced

AO Classification of diaphyseal femur fracture [23]

A = Simple fracture

32 – A1	Simple fracture, spiral
32 – A2	Simple fracture, oblique
32 – A3	Simple fracture, transverse

B = Wedge fracture

32 – B1	Wedge fracture, spiral wedge
32 – B2	Wedge fracture, bending wedge
32 – B3	Wedge fracture, fragmented wedge

C = Complex fracture

32 – C1	Complex fracture, spiral
32 – C2	Complex fracture, segmental
32 – C3	Complex fracture, irregular.

<u>FRACTURE PATTERNS</u>:

Femoral neck fracture in this situation is usually a **vertical fracture which is undisplaced or minimally displaced**[2] because of the dissipation of energy in producing fracture of the femoral shaft**.**

Femoral shaft fracture is usually situated in the middle of the shaft and is usually comminuted[2] because of the high energy violence.

In our series more than 50% of the femoral neck fractures were displaced and more than half of the shaft fractures were comminuted according to Winquist and Hansen classification.

> **20% - 60% of the neck fractures in double level femur fractures are undisplaced**[22]
>
> **Ostrum & Poka - 1999**

TREATMENT OPTIONS:

Non operative treatment for these devastating injuries is almost never advocated and if chosen it is usually a choice of exclusion[6].

Indications for non operative treatment:

1) Non ambulatory patents
2) Elderly patient whose medical condition carries a high anesthetic risk

OPERATIVE TREATMENT:

These complex fractures have been treated traditionally by surgical stabilization ever since they were first described. The results of non operative treatment were not satisfactory. The early fixation devices also fell short of expectations resulting in increased incidences of surgery related complications.

The initial fixation devices used were Knowles pins and Kuntscher nail. More than 60 methods of fixation have been described since then. Better understanding of the fracture patterns and improved biomechanics of fixation devices have helped in achieving rigid fixation and producing more predictable results.

EVOLUTION OF SURGICAL TECHNIQUES:

KUNTSHER NAILING & KNOWLES PINS

↓

ENDER NAILS & HIP SCREWS

↓

COMPRESSION PLATING & CANCELLOUS SCREWS

↓

RECONSTRUCTION NAILS

↓

RETROGRADE NAILING & CANCELLOUS SCREWS

These fractures were treated initially following the Lambotte's principles of precise reduction, temporary stabilization and definitive fixation. The neck fractures were first reduced and fixed with Knowles pins followed by fixation of the shaft fracture using Kuntscher nail. This type of fixation was inferior for many reasons. The pins used for fixing the neck fracture **did not allow for compression** at the fracture site, they were also **biomechanically inferior** and they **allowed loss of reduction while passing in the nail**[7].

After passing the pins, inserting the nail was also more difficult and the Kuntscher's nail had **poor rotational control**[7] and was found wanting in maintaining the length as the shaft fracture was most often comminuted[7]. Non availability of image intensifier also made surgical treatment of these fractures a lot more difficult.

Subsequently many types of fixation came into vogue claiming to be better than one another. They all produced variable results which could not be reproduced universally and the ideal method of fixing these fractures remained elusive.

When AO principles of rigid fixation came to be globally followed, almost every other fracture was fixed using plates providing compression across the fracture site and these fractures were no exception. Compression plating for shaft fractures and cancellous screws or sliding hip screw for neck fractures became the standard method of fixation of these fractures[23]. This type of fixation holds good even today but requires extensile exposures with massive soft tissue stripping and increased rates of infection. There were also increased rates of delayed union, angular malunion and unacceptable shortening in complex shaft fractures.

17 patients with ipsilateral neck & shaft fractures treated by plating and cancellous screws or sliding hip screw and achieved 100% union of neck # and 77% union of shaft # but union of shaft # was delayed and rates of infection were increased. They concluded that compression plating with c.screws or SHS is a satisfactory procedure[18].

(Khallaf F, Al – Mosalamy – 2005)

With the advent of image intensifier, closed interlocking nailing techniques were introduced and popularized by Kempf et al[19]. Closed interlocking nailing became the standard for surgical treatment of femoral shaft fractures and was extended for these complex fractures also with supplemental screw fixation into the neck. In this technique the neck fracture was initially reduced and fixed with cancellous screws leaving space for passing the nail. If the neck fracture was diagnosed during the nailing procedure they were fixed following the nailing procedure with screws anterior and posterior to the nail.

Leung et al achieved 100% union of both neck and shaft fractures in 16 patients treated with centromedullary nail and supplemental screws[20]

Technical difficulties in fixing the neck fracture with antegrade nailing techniques led to the use of condylocephalic nails such as Ender's nail. These were combined with sliding hip screw for treating these complex fractures. However these fixation devices were never rigid enough to become universally accepted and they also had their own share of complications like nail backout, angular malunion and delayed rehabilitation [12].

The Russel – Taylor reconstruction nail was exclusively designed for the purpose of treating these complex fractures. The RT nail had two cephalomedullary locking holes proximally which were inclined at an angle of 135° which allowed insertion of two 6.4 mm locking screws into the femoral neck through the nail under the guidance of the image intensifier. The cephalomedullary nails revolutionized the treatment of these complex fractures and lots of studies were published producing excellent results with the RT nail[6,9,15,17]. The procedure is technically demanding and the learning curve is long but yields good results when the technique is meticulously implemented[15].

RECON nail is an acceptable implant for ipsilateral neck & shaft #s[17]

(Wu CC et al – 2006)

RECON nail is a satisfactory implant in treatment of ipsilateral hip & shaft fractures but is technically demanding[9]

(Maini L et al – 2004)

When the reconstruction nails became the popular, another potential complication surfaced which was increased incidence of avascular necrosis of the femoral head following insertion of the nail through the piriformis fossa. Though this theoretical implication was never proved significant interest was renewed in alternate forms of fixation.

This led to many modifications and improved designs in the category of Reconstruction nails followed. The entry point was shifted from piriformis fossa to the tip of the trochanter to facilitate easy nail insertion and to reduce the shear forces at the neck and preventing loss of reduction and decrease AVN incidence. To achieve this, nails were manufactured having a proximal mediolateral bend of 6°. The nails also incorporated an anterolateral curvature to match the anatomical shape of the femur. The cephalomedullary locking holes also became available in different angles to allow for varying neck shaft angles.

The SIRUS nail designed by **Christopher Josten** of Germany fulfilled the above specifications. It also provided an anterior slot to insert a third screw into the neck using the 'MISS THE NAIL TECHNIQUE'. It also has multiple proximal and distal transverse locking options to allow better control, reduction and fixation of the shaft fracture.

Starr et al made a study comparing **piriformis fossa & trochanteric entry portal** in these complex fractures.

There was no difference with respect to amount of blood loss, incision length and complications especially AVN[27]

(Starr et al – 2006)

The AO proximal femoral nail was designed initially for the treatment of trochanteric fractures. With the availability of its longer version its indications have been extended to treat these complex femoral fractures. The use of a larger (8 mm) screw with an anti-rotation screw theoretically provides better stability especially in basicervical fractures.

Long PFN is a quality implant and most beneficial in the category of reconstruction nails for treating complex femoral fractures[24].

(Pavelke T, Lihart M – 2005)

All these antegrade nailing techniques however modified are technically demanding. The control of neck fracture is difficult especially when it is displaced because even if they are reduced closed they are prone to displacement during the nailing procedure. Fixing the shaft fracture first may compromise the placement of neck screws. So the search for a better implant continued.

Retrograde nailing through an intra articular entry portal combined with cancellous screw fixation has renewed interest in surgical fixation of these fractures[32]. This type of fixation allows both fractures to be reduced and fixed independently. The surgeon has better control over these fractures and the procedure is also technically easier with a shorter learning curve. They are complicated by documented episodes of recurrent knee effusions and the potential to cause septic arthritis of the knee. They can also cause a stress riser effect at the subtrochanteric region.

Inspite of the availability of various types of implants consistent recommendations for the treatment of these fractures have not been forthcoming. At present cephalomedullary nails, retrograde nailing with screw fixation and compression plating with screw fixation are considered viable treatment options for these fractures.

Role of prosthetic replacement:

These patients are usually young and so the indications for prosthetic replacement are minimal [35].

1) Pathological fractures
2) Long stem prosthesis with cable fixation may be used in case of elderly patients with upper shaft fracture
3) Prosthetic replacement for the neck fracture combined with retrograde nailing may also be indicated for lower levels of shaft fracture in old patients
4) Revision of femoral neck non unions in elderly patients

Yip KM et al used a customized long stem AM prosthesis with half sawed GK nail for these fractures with good results in old patients[35].

SURGICAL TECHNIQUES

TIME OF SURGERY:

Fracture of the femoral neck is a surgical emergency because of the increased incidence of avascular necrosis. Though there is no conclusive evidence early stabilization of these fractures may actually decrease the incidence of avascular necrosis. Fractures stabilized within 48 hrs may have a favourable prognosis[6].

CEPHALOMEDULLARY NAILING:

In cephalomedullary nailing reduction of the neck fracture is done first for the following reasons.

1) Reducing and fixing the shaft fracture initially may cause difficulty or inability to place two cephalomedullary screws thus compromising neck fixation.
2) Inability to reduce the neck fracture in a closed manner may also help in deciding a different implant since the application of cephalomedullary nailing in displaced neck fractures is difficult

Nearly half of the neck fractures are undisplaced and cephalomedullary nailing can be performed safely in these situations. A third generation nail with a trochanteric entry point is preferable. Nail length should be measured preoperatively and the longest nail possible should be chosen. Appropriate length of the neck screws required should be noted using the pre op x rays.

The patient should be positioned on a fracture table with boot traction or traction through an upper tibial pin. Supine position is preferred and use of image intensifier in two planes is absolutely necessary. Preliminary reduction of the neck fracture is done if required and is confirmed by the image intensifier in two planes.

If reduction of the neck is satisfactory then an appropriate sized nail is passed following the usual steps in interlocking nailing. Shaft fracture is reduced either closed or open and the nail is passed into the distal shaft fragment. This is followed by appropriate placement of guide wires into the femoral neck over which the neck screws are inserted after confirming the guide wire position using image intensifier. The neck screws should have proper purchase in the subchondral bone to prevent implant failure.

A third screw may be inserted by MISS THE NAIL TECHNIQUE if available for better fixation but it is more often not necessary. The shaft fracture is then locked in a static manner with the distal screws using free hand technique or the distal targeting jig if available.

RETROGRADE NAILING:

In retrograde nailing the shaft fracture is reduced and fixed first and this gives the surgeon an opportunity to reduce the neck fracture anatomically in case it is displaced by applying traction to the involved extremity.

The approach can be either extensile by everting the patella or a percutaneous approach through the patellar tendon using a tissue protection sleeve. Entry point is made in the intercondylar notch just anterior to the insertion of posterior cruciate ligament with a sharp bone awl. Guide wire is passed into the distal fragment holding the fracture reduced and the entry point is widened with a cannulated reamer and the nail is passed after appropriate reaming with the help of a jig. Proximal and distal locking are done in the usual manner. The proximal tip of the nail should be properly buried inside the medullary cavity for atleast 0.5 cm to prevent irritation of the knee. The distal tip of the nail should reach the level of the lesser trochanter to minimize stress riser effect.

The neck fracture is reduced if required using traction and fixed with three cancellous screws in an inverted triangle pattern following the standard techniques. A sliding hip screw may also be used especially in a basal fracture.

COMPRESSION PLATING WITH NECK SCREWS:

A fracture table is not needed. Patient is positioned laterally with the injured limb facing upwards on a radiolucent table. Through lateral or posterolateral approach to the shaft of femur, the shaft fracture is exposed and fixed by following the standard principles of reduction. A broad DCP of 8 – 12 holed is usually used depending on the fracture configuration. The neck fracture is reduced and fixed with cancellous screws or DHS as described above.

OPEN FRACTURES:

Incidence of open fractures in this fracture combination is low and if open the wound is situated usually at the site of the shaft fracture. Principles of open fracture management should be followed for optimal results [16].

In a series of 25 patients only 4 patients had an open fracture. All were either types 1 or 2 according to the Gustilo – Anderson classification and all were at the site of the shaft #[13].

(Guvenir okcu et al, 2003)

ASSOCIATED INJURIES:

Multisystem injuries include head injuries, chest injuries and abdominal visceral injuries. Injuries to the other parts of the skeleton are common most commonly injuries to the ipsilateral knee.

POST OPERATIVE CARE:

Patients who had a rigid fixation should be mobilized immediately on POD 1 as pain allows. Range of motion exercises of the knee and ankle should be carried out to full range and the hip range of motion should be in the painfree zone. Once the patient attains good control over his injured limb partial weight bearing can be allowed with the help of a walker depending on the configuration of the shaft fracture, type of locking {static or dynamic}, rigidity of the implant and the stability of the neck fracture. Hip strengthening exercises are also started by this time especially strengthening of the abductors. Weight bearing can be progressed gradually and the patient is followed up with serial x rays.

Full weight bearing is allowed only after radiological evidence of union.

ROLE OF BONE GRAFTING:

Primary bone grafting for the shaft fracture is not usually advised if reduction can be achieved in a closed manner. Opening the fracture site and letting the fracture hematoma out for the purpose of bone grafting is not a fruitful option. Delayed bone grafting may be used after 6 weeks if there is delay in progression to union [21]. However primary bone grafting may be indicated in open surgical techniques depending on the fracture configuration.

COMPLICATIONS

NON UNION:

The average incidence of non union of the shaft fracture ranged from 2% - 10% and for the neck fracture it is around 2% - 4% in this injury pattern. Non union of the shaft is easier to treat than femoral neck nonunions. They can be treated by dynamization with or without bone grafting or if the femoral neck healed and consolidated exchange nailing is a better procedure. **Treatment of femoral neck non unions depend on whether neck reduction was anatomic and placement of the screws achieved compression at the femoral neck. If the femoral neck nonunion did not shorten or undergo varus collapse revision is simple, with conversion to a compression hip screw device[33].**

{Wu et al, 1999}

If a femoral neck nonunion develops more than 1 cm of shortening, any varus malalignment, or both, a valgus intertrochanteric osteotomy is the treatment of choice. In this way, the neck shaft angle is restored, compression at the nonunion site is obtained, and the leg length discrepancy is corrected. The current results using this technique are similar to those of other authors who have shown high rates of fracture union with low rates of avascular necrosis of the femoral head [30].

(Wiss DA et al – 1999)

MALUNION:

Unacceptable malunion is not common in shaft fractures. Even if they occur sagittal or coronal malalignment is minimal 4° {range 3° - 5°}in a large series[1] by {Kemal Actuglu et al 2003} which does not produce any functional impairment. Varus malunion of the neck is a more common problem in these fractures. They are usually treated by an intertrochanteric valgus osteotomy and fixation if it causes unacceptable shortening [1].

SHORTENING:

Shortening if present is minimal in the range of 1 – 2 cm and can be managed with a heel and sole rise if required. Greater amounts of shortening are best managed by an intertrochanteric valgus osteotomy to gain length. Shortening may be greater in cases treated by compression plating due to loss of length in the region of the shaft in addition to the varus collapse of the neck fracture.

INFECTION:

Incidence of infection in any large series ranges from 1% - 2%[16]. Deep infection is rare and if occurs should be treated aggressively with intravenous antibiotics & drainage. Implant should be retained if providing stability but may have to be removed if it is unstable or if the infection is not responding. Fracture stability should be restored temporarily with an antibiotic coated nail which will also help in controlling infection.

AVASCULAR NECROSIS:

Incidence of avascular necrosis range from 9% - 35% arrived from various large studies. **It was found that delay in surgical fixation had no influence on AVN in this type of fractures. AVN in these types of injuries can occur even after 10 years [5,6,7,32].**

THROMBOEMBOLIC COMPLICATIONS:

These fractures are usually a result of high energy trauma and so these patients have a high risk of thromboembolic complications. Fat embolism in long bone fractures usually occur around 48 – 72 hours. These patients should have their fractures splinted properly and should be monitored intensively for features of pulmonary embolism. Early surgical fixation of these fractures within 48 hours may help prevent this life threatening complication[6].

HIP ABDUCTOR WEAKNESS:

Minor degree of hip abductor weakness is common after cephalomedullary nailing, but it is always transient and never severe enough to impair function. Abductor weakness may be more common after nailing procedures which use piriformis fossa entry portal due to increased muscle dissection [7].

KNEE STIFFNESS:

Decreased range of motion of the knee is common after these injuries because rehabilitation in these patients may be delayed due to other life threatening injuries. Patients who undergo late surgical fixation and patients who are treated by retrograde nailing are also prone for this complication unless they are rehabilitated properly.

LOSS OF FIXATION:

Problems with fixation are more common with neck fractures. If loss of reduction in a neck fracture occurs, available options are

1) acceptance of the deformity
2) revision ORIF
3) conversion to prosthetic replacement

Acceptance of the deformity should be considered in marginal ambulators who are a poor surgical risk. Revision ORIF is indicated in younger patients, while prosthetic replacement (unipolar, bipolar or total hip replacement) is preferred in the elderly patient with osteoporotic bone[36].

(Zetas et al – 1981)

MATERIALS AND METHODS

25 patients with ipsilateral neck and shaft fractures who underwent cephalomedullary nailing at our institution were included in our study. 22 were males and 3 were females. 17 fractures were on the right side and 8 on the left side. The age of the patients ranged from 17 – 64 years. The period of study was from June 2004 to June 2006. All patients were followed regularly and the average period of follow up was 16.2months (7 – 24 months).

INCLUSION CRITERIA:

Patients with neck fracture either intracapsular or basal and a concomitant shaft fracture extending from proximal third to the distal third were included in the study. Patients with supracondylar or intercondylar fractures of femur were excluded. Patients less than 15 years were excluded. Compound fractures above grade IIIA according to the Gustilo – Anderson classification were not included.

We operated upon 28 patients fulfilling the above criteria. Of them 25 patients were included for final analysis. Of the excluded patients one had an associated spinal injury with complete paraplegia, one had a fat embolism preoperatively and an alternate method of fixation was undertaken and the last patient had an incomplete fixation due to technical difficulties.

All patients included for final analysis underwent cephalomedullary nailing. Patients with multiple injuries were also included.

All patients were classified according to the AO system of classification the neck fracture was subcapital in 1 patient, transcervical in 5 patients and basal in 19 patients. The neck fracture was undisplaced in 6 patients, minimally displaced in 13 patients and grossly displaced in 6 patients. The shaft fracture was most often in the mid 1/3 – 17 cases, proximal 1/3 – 1 case, and distal 1/3 – 7 cases. 15 patients had comminuted shaft #. The fracture was compound in 7 cases (compound grade 1**-** 4 cases, compound grade 2 **-** 3 cases.). All cases were due to high energy trauma. Additional bony injuries were present in 10 patients (40%) including tibial shaft fractures, tibial plateau fractures, #s of the patella, olecranon, distal radius and forearm. **The neck # was missed in 2 patients in the initial radiographs** but was made out in the subsequent radiographs before nailing. The implants used were RECON NAIL – 6 cases, SIRUS NAIL – 10 cases and LONG PROXIMAL FEMORAL NAIL IN 9 cases.

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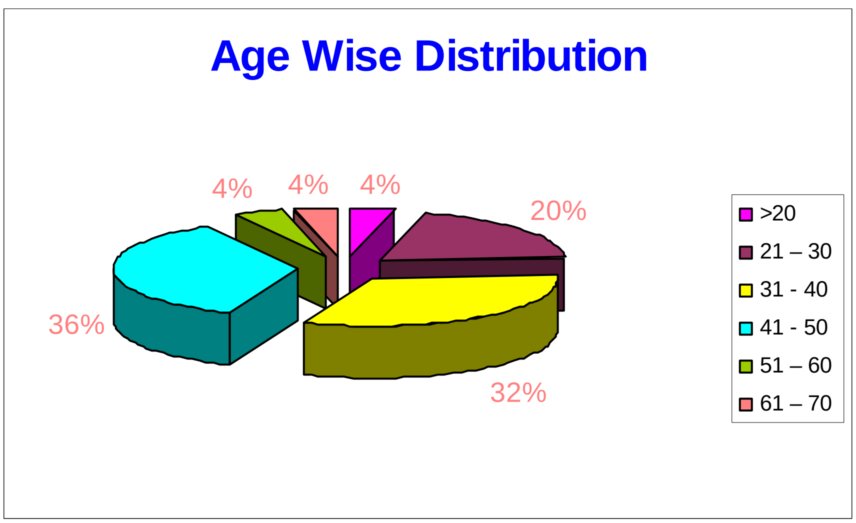
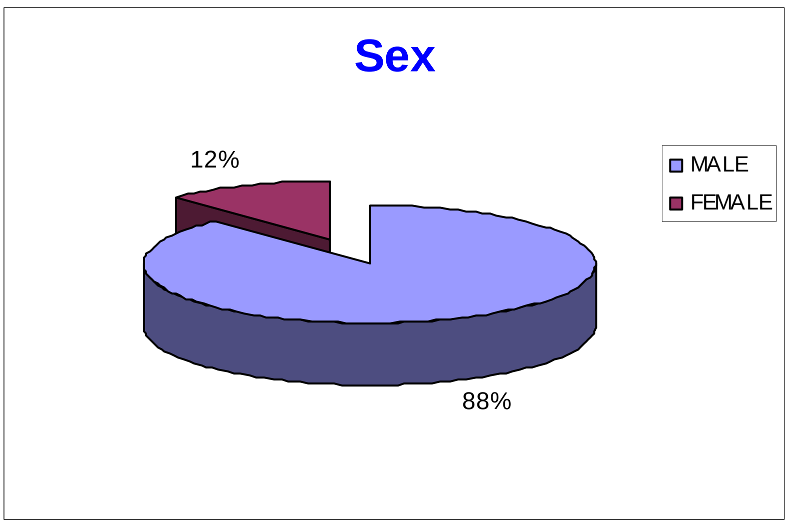
Age group	CEPHALOMEDULLARY NAILING	
	No. of Patients	Percentage
16 – 20	1	4
21 – 30	5	20
31 - 40	8	32
41 - 50	9	36
51 – 60	1	4
61 – 70	1	4
TOTAL	25	100
MEAN	38.08 years	



SEX	CEPHALOMEDULLARY NAILING	
	No. of Patients	Percentage
MALE	22	88
FEMALE	3	12



INJURY PROFILE

S.No.	Neck		Shaft		Compound #
	AO	Displacement	AO	Comminution	
1	B1.3	D	A3.2	0	C
2	B2.1	ND	B2.2	1	C
3	B2.1	ND	B3.2	3	C
4	B2.1	D	A2.2	0	Gr. I
5	B2.3	D	A2.2	1	C
6	B2.1	D	B2.1	1	C
7	B2.1	ND	B2.3	2	Gr.I
8	B2.1	D	B3.2	2	Gr.II
9	B2.1	ND	B3.3	0	C
10	B2.1	D	A3.2	0	C
11	B2.1	ND	B2.2	1	C
12	B2.3	D	A2.3	0	C
13	B2.1	ND	B2.2	3	C
14	B2.3	D	B2.2	1	C
15	B2.1	D	B2.2	0	Gr.II
16	B2.1	ND	A3.3	0	C
17	B2.1	ND	A3.2	2	Gr.I
18	B2.3	D	A3.2	0	C
19	B2.1	ND	B3.2	1	C
20	B2.1	ND	A3.3	0	Gr.II
21	B2.1	D	A3.3	0	C
22	B2.3	D	B2.2	3	C
23	B2.1	D	B2.2	3	Gr.I
24	B2.1	ND	A3.3	1	C
25	B2.1	D	B2.2	2	C

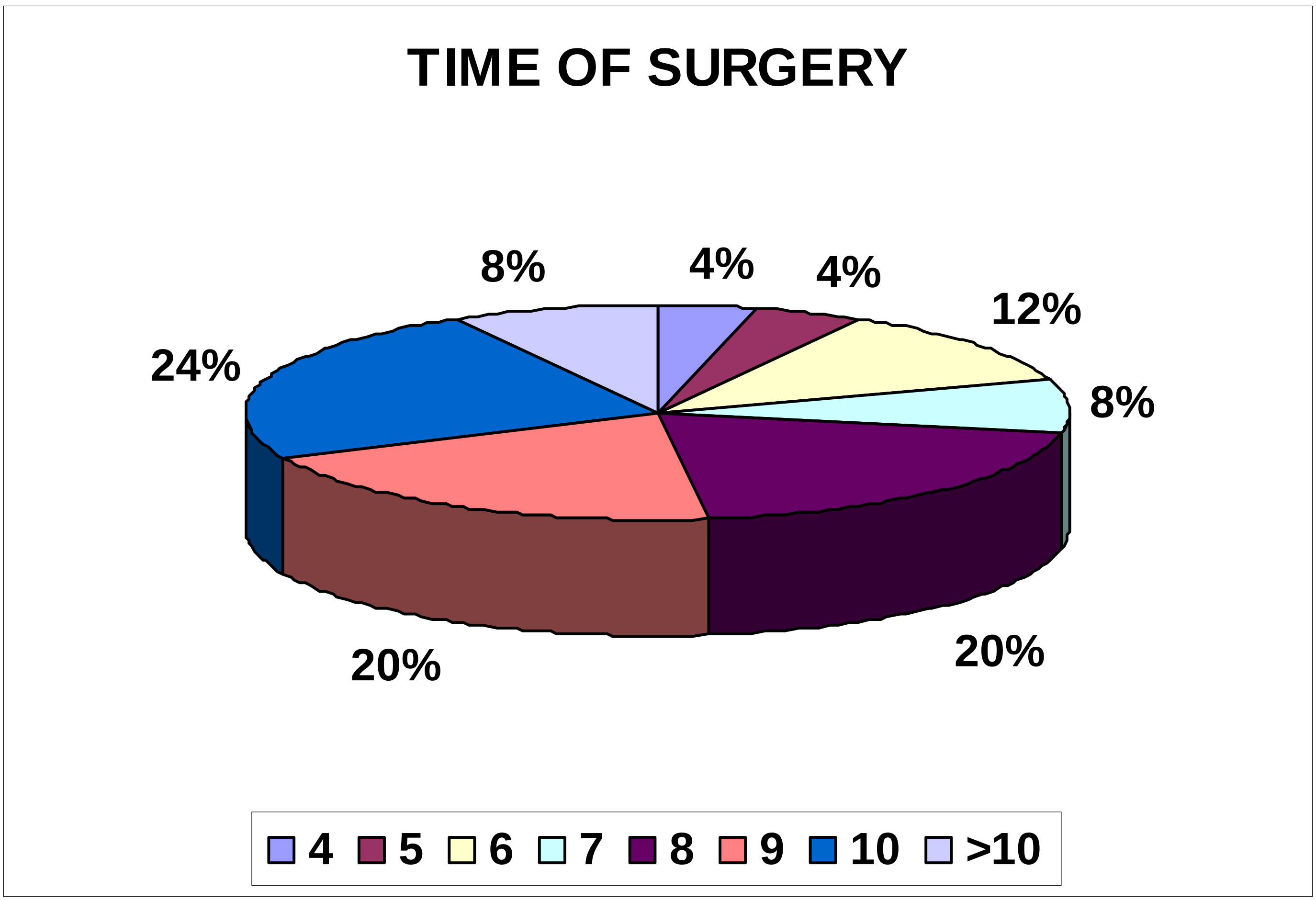
D = Displaced, ND = Undisplaced
Comminution = Winquist & Hansen classification types
C = Closed #, Gr.I & II = Gustilo & Anderson types

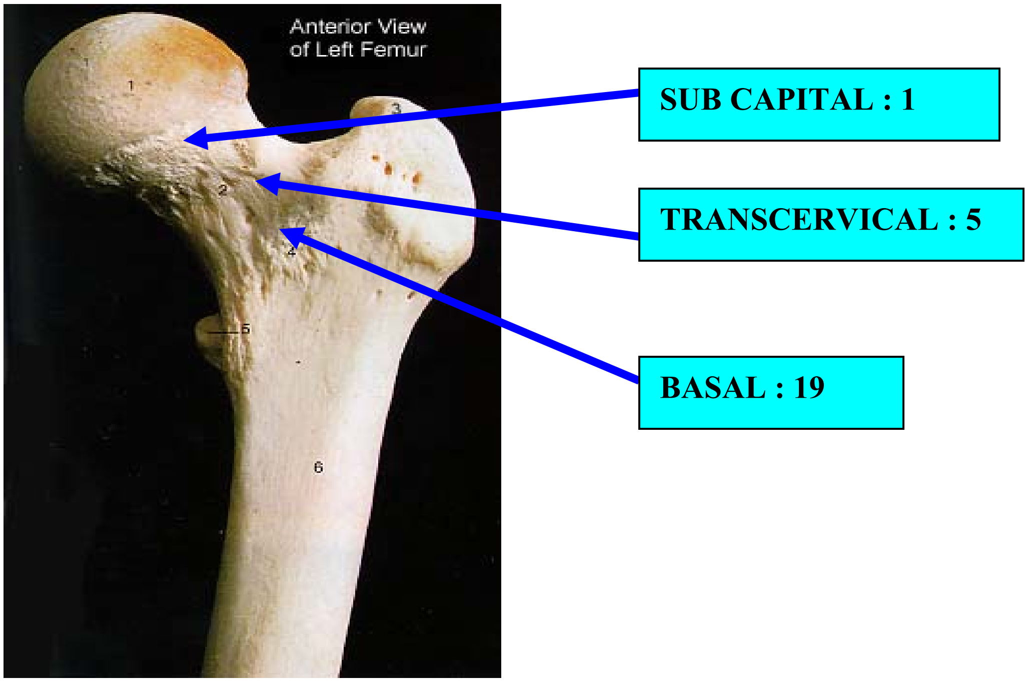
TIME OF SURGERY

INTERVAL	CEPHALOMEDULLARY NAILING	
	No. of Patients	Percentage
4	1	4
5	1	4
6	3	12
7	2	8
8	5	20
9	5	20
10	6	24
>10	2	8
TOTAL	25	100
MEAN	10.12 days	

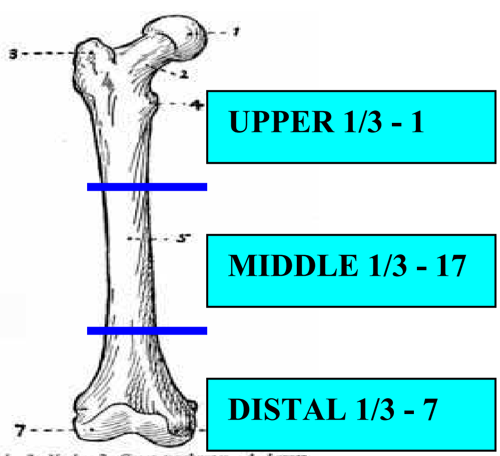
Time of Surgery	No. of Patients	Percentage
≤8 days	12	48
>8 days	13	52

Functional results were better in patients undergoing early surgery.


TIME OF SURGERY
8%
4%
4%
12%
24%
8%
20%
20%
4
5
6
7
8
9
10
>10



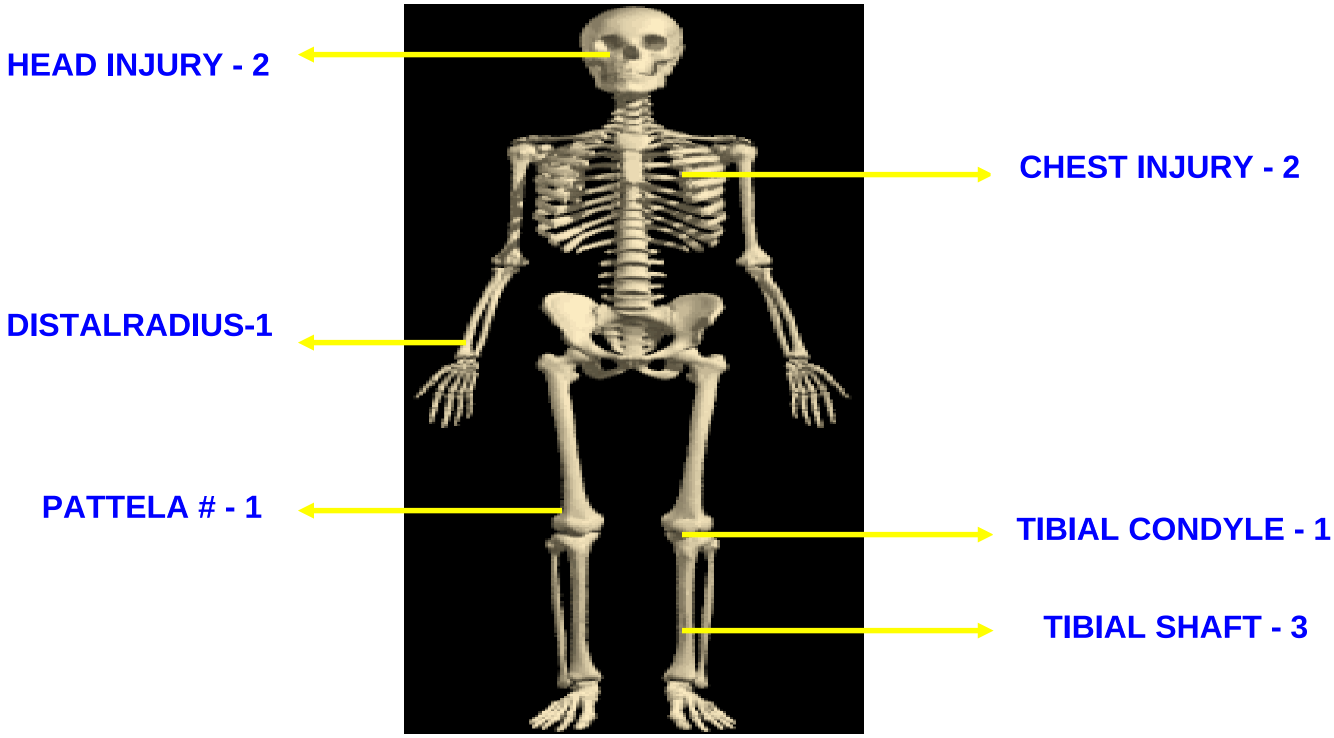
Basicervical fractures comprised 75% of all neck fractures in our series.



1. Head. 2. Neck. 3. Great trochanter. 4. Lesser trochanter. 5. Shaft. 6. Inner condyle. 7. Outer condyle.

The shaft # was often in the middle and comminuted.

ASSOCIATED INJURIES



PRE OPERATIVE PLANNING:

Pre operative templating with AP and lateral radiographs of the injured hip and thigh were used to assess fracture displacement, plan methods of reduction and to measure the nail diameter and the length of the neck screws.

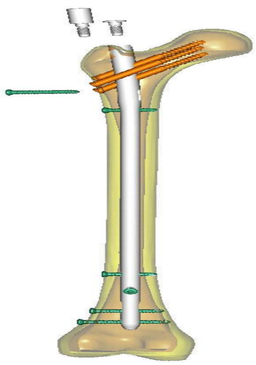
PRE OP SKELETAL TRACTION:

All patients were put on skeletal traction pre operatively by means of upper tibial or lower femoral pins till they were taken up for definitive surgical stabilization.

IMPLANTS AND INSTRUMENTATION:

We used three different types of cephalomedullary nails in our study.

SIRUS nail - 10



RECON nail - 6

Long PFN - 9

Instrumentation:

Targeting jig: for proximal locking

Guide wires: 2 mm

Cannulated distal reamers: 8, 9, 10, 11 and 12mm

Proximal reamer: 14 mm to accommodate the proximal end of the nail

Guide wire sleeve and drill sleeves

Cannulated drill bits and tap: for neck screw insertion

Cannulated screw driver

Guide pins for neck screw insertion

ANAESTHESIA, POSITIONING & IMAGE INTENSIFIER:

All cases were operated under regional anaesthesia (spinal or epidural). The patient was positioned supine on a standard radiolucent fracture table with boot traction. A single image intensifier was used in two planes.

Surgical technique:

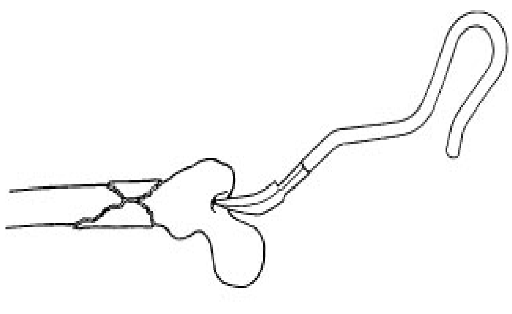
Closed reductions of both fractures were attempted initially in all cases. **All neck fractures were reduced in a closed manner in our series. We resorted to open reduction after failure of CR for 4 shaft fractures which were operated after 8 days**.

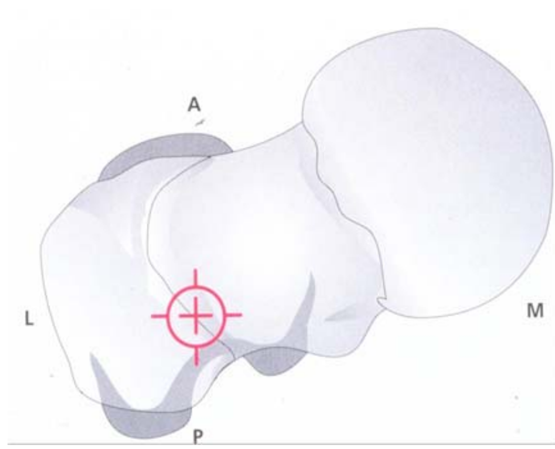
Incision:

We used a small incision of around 3 cm with its distal end on the tip of the trochanter in case of SIRUS nail or a PFN. A slightly longer incision was used with Recon nails. The entry point is identified after careful dissection. A tissue protector sleeve was used to protect the soft tissues during proximal reaming. If open reduction of the shaft fracture is required it is done through a standard lateral approach.

Entry point:

The entry point was either the tip of trochanter (PFN or SIRUS) or the piriformis fossa for Recon nails.





Guide wire insertion & reaming:

The guide wire is inserted and is passed into the distal shaft fragment after reducing the shaft fracture. After C – arm confirmation the entry point is widened using a 14 mm cannulated proximal reamer. Distal reaming of the canal is done with graded cannulated solid reamers.

Nail insertion & Proximal targeting:

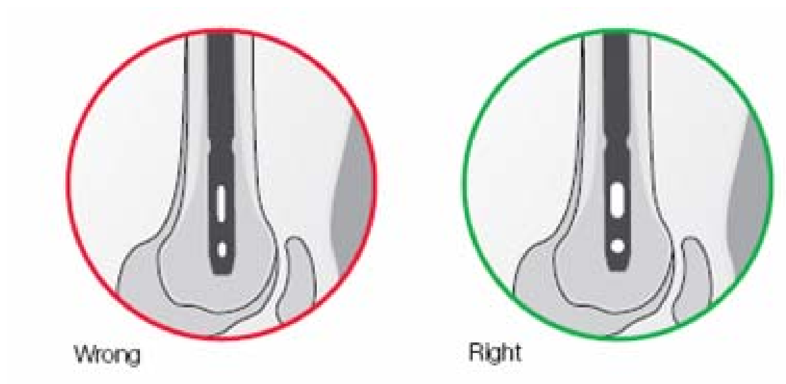
The nail is inserted with the help of the jig over the guide wire. Flouroscpic images are taken to look for any displacement of the neck fracture. The nail is inserted by hand using gentle rocking movements. Once the nail is positioned appropriately, the guide wire is removed and drill sleeves are attached to the jig and through a lateral stab incision they are pushed upto the lateral cortex. The guide pin is passed and advanced to 5 mm from the articular surface of the femoral head.

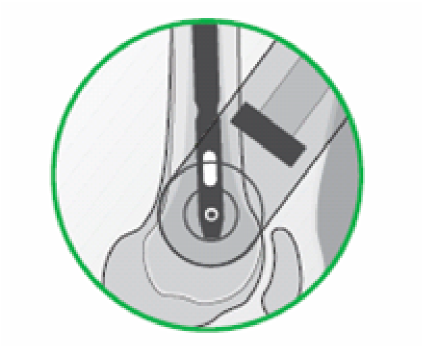
Proximal locking is done with two cannulated cancellous screws of various lengths as measured. The anti rotation screw is inserted first in case of PFN followed by insertion of the main hip screw. The anti rotation screw is also chosen 15 mm short to prevent screw cut out.

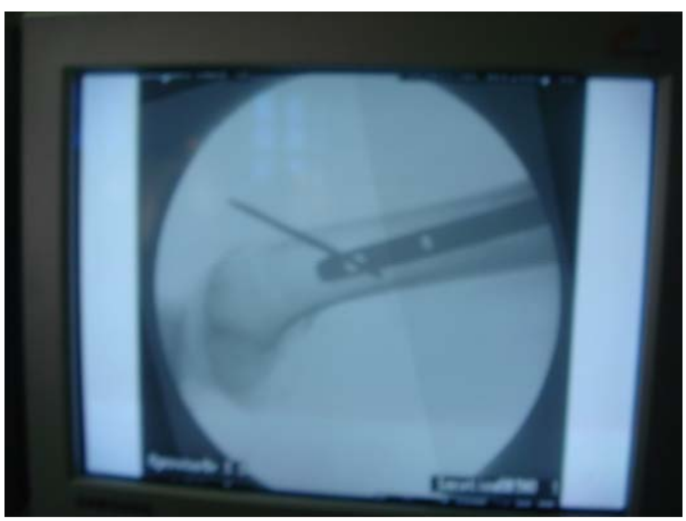
Only two screws through the nail were used for all neck fractures. The miss the nail slot was not used in any of our cases.

<u>Distal targeting</u>:

Distal locking is done by free hand technique using one or two 4.9 mm locking bolts with the help of image intensifier.







POST OPERATIVE REGIMEN:

Post operatively early ROM exercises to the hip, knee and ankle were allowed. Patients were kept non weight bearing for 6 weeks to protect the neck fracture from displacement. Toe touch weight bearing with progression to partial weight bearing was allowed after 6 weeks. After 6 weeks hip abductor strengthening exercises were started. Full weight bearing was allowed after evidence of bridging callus on the radiographs. Weight bearing was delayed for 12 weeks in cases with associated tibial plateau fractures.

RESULTS

The operating time was calculated from the start of surgical incision to wound closure. The operating time gradually improved with our experience. It varied from 65 min to 135 min. The blood loss was calculated from the number of surgical mops used each corresponding to 50 ml. Blood loss in our series varied from 100 to 250 ml. The duration of image intensifier usage was calculated in seconds. It varied from 50 – 140 seconds.

All fractures were followed to union. Radiological union was defined as obliteration of the fracture line in two planes. Union was considered to be delayed if the fracture line is still visible or there is failure in progression at 24 weeks. All neck fractures united after primary fixation. The mean time for radiological union of neck fracture was 16.28 weeks. There were **no incidences of AVN at a follow up period of 16 months** and the neck shaft angle was restored in all but two patients who had a varus malunion but both these patients had a good functional result. There was no screw cut out or loss of reduction in any of our cases. The mean time of radiological union of shaft fractures was 20.6 weeks**. Union of shaft fracture was delayed in 3(12%) patients**, one or these patients underwent delayed bone grafting at 8 weeks and no fractures were dynamised. Distal locking screw breakage was seen in two patients. The fracture configuration in both these patients was transverse, they were encouraged weight bearing and they had a successful union as a result of autodynamisation.

The latest follow-up examination revealed that in 19 patients the average hip and knee motion was atleast 90% of that of the opposite side and pain-free. Knee ROM was just over 90° in 4 patients (two had a concomitant tibial plateau fracture, one had a tibial shaft fracture and one patient was operated after 42 days of traction). There was no ligamentous instability of the knee in any case. Two patients had mild knee pain but not severe enough to necessitate the use of analgesics. All patients regained their pre-injury level of independence.

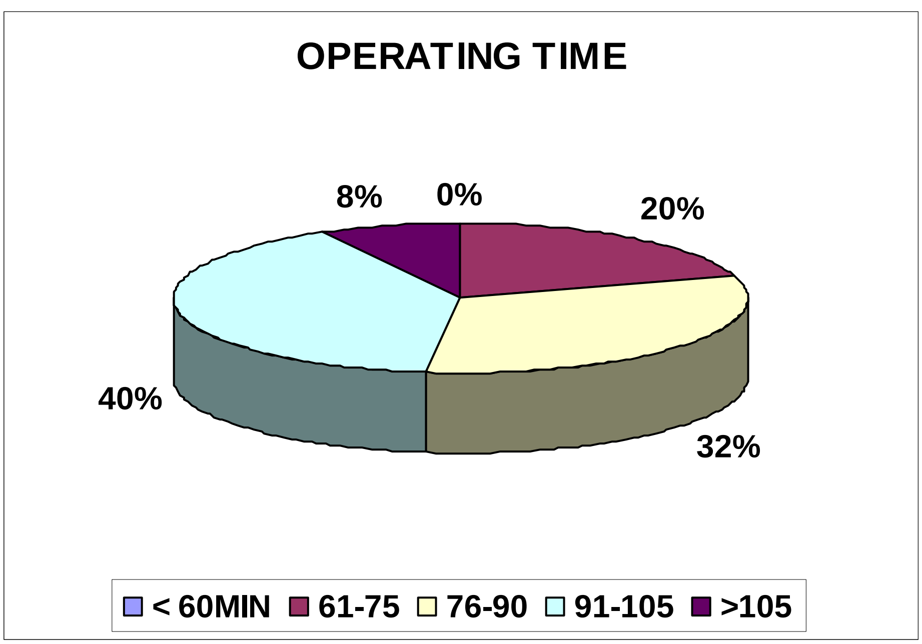
In 2 patients, the femoral neck fracture was initially unrecognized in the emergency department (8%) but was subsequently identified before definitive surgery. Superficial infection occurred in 4 patients but resolved uneventfully. One patient developed deep infection after 1 month of surgery and was reoperated with drainage and i.v antibiotics. The infection resolved completely and the patient progressed to union.

Four patients required reoperation (one for deep infection, one for delayed grafting, one for retrieval of a slipped proximal locking screw during the procedure and one for removing an entrapped suction drain).

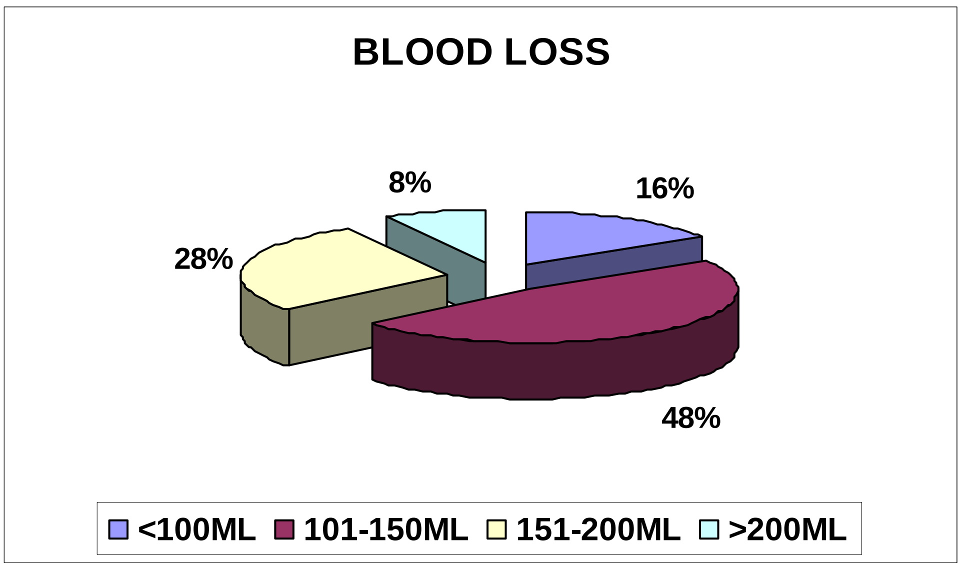
Transient abductor weakness was present in 2 patients treated with a RECON nail with entry through the piriformis fossa. We did not encounter fat embolism or ARDS in any of our cases. Shortening was present in 6 patients (24%) averaging 1.6 cm. These patients did not have any functional impairment.

OPERATING TIME	CEPHALOMEDULLARY NAILING	
	Number of Patients	Percentage
< 60 MIN	NIL	0
61 – 75	5	20
76 – 90	8	32
91 – 105	10	40
> 105	2	8
MEAN	93.88 minutes	

OPERATING TIME	
Initial 13 cases	101.46 minutes
Last 12 cases	85.67 minutes



BLOOD LOSS	CEPHALOMEDULLARY NAILING	
	Number of Patients	Percentage
< 100 ML	4	16
101 – 150 ML	12	48
151 – 200 ML	7	28
> 200ML	2	8
MEAN	172 ml	

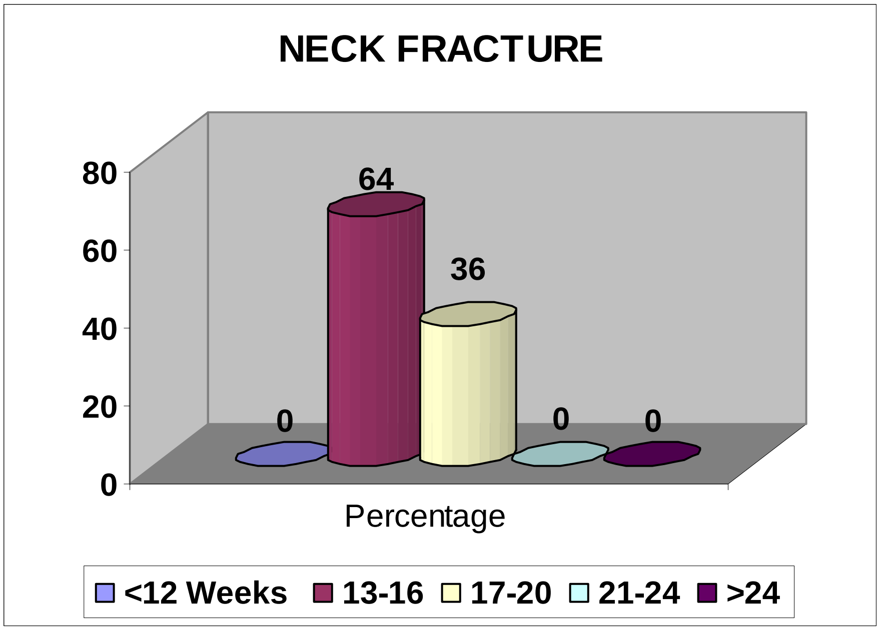


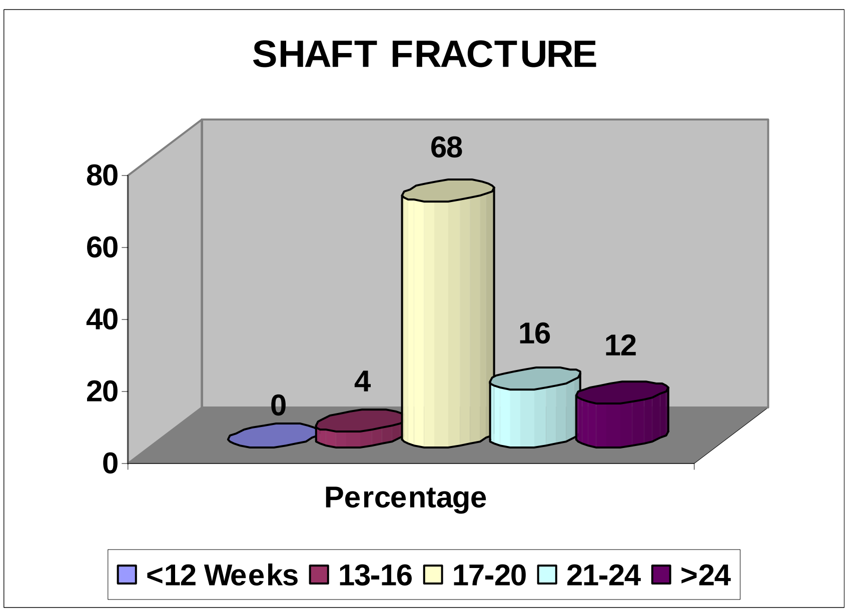
FLUOROSCOPY	
Initial 13 cases	85.85 seconds
Last 12 cases	55.75 Seconds

TIME TO UNION	CEPHALOMEDULLARY NAILING				
NECK #	Number	%	SHAFT #	Number	%
< 12 WEEKS	NIL	0	< 12 WEEKS	NIL	0
13 – 16	16	64	13 – 16	1	4
17 – 20	9	36	17 – 20	17	68
21 - 24	NIL	0	21 - 24	4	16
>24	NIL	0	>24	3	12
MEAN	16.28 weeks		MEAN	20.6 weeks	

UNION OF THE SHAFT FRACTURE DETERMINED THE OUTCOME IN OUR STUDY.

TIME TO UNION





Our functional results were analyzed using the scoring system introduced by Friedman and Wyman in his classic article in 1998.

Friedman & Wyman functional recovery score[10]:

Good:

No limitations in activities of daily living
No pain
<20% loss of hip and knee motion.

Fair:

Mild limitations in ADL
Mild to moderate pain
20 – 50% loss of hip and knee motion

Poor:

Moderate limitations in ADL
Severe pain
>50% loss of hip and knee motion

Friedman & Wyman, 1986

Friedman and Wyman score	GOOD	FAIR	POOR
No. of .Patients	19	6	0
Percentage	76	24	0

We had good functional results in 19 patients. 6 patients had a fair result (4 due to restricted knee motion and 2 due to mild knee pain). We did not encounter any bad results. **Our good results correlated with patients taken up for surgery earlier.**

RESULTS - SUMMARY

PARAMETERS	VALUES	
OPERATING TIME	93.88minutes	Initial 13 cases 101.46 minutes
		Last 12 cases 85.67 minutes
BLOOD LOSS	172 ml	
FLUROSCOPIC EXPOSURES	71.4 seconds	Initial 13 cases 85.85 seconds
		Last 12 cases 55.75 seconds
FRACTURE UNION		
NECK	16.28 weeks	
SHAFT	20.6 weeks	
NON UNION	Nil	
MALUNION		
NECK	Varus malunion in 2 patients	
SHAFT	Nil	
AVN	Nil	
SHORTENING	6 (24%) patients (average 1.6 cm)	
INFECTION		
SUPERFICIAL	2 patients	
DEEP	1 patient (4%)	
HARDWARE FAILURE	2 patients	
HIP ABDUCTOR WEAKNESS	2 patients	

STATISTICAL ANALYSIS

The results obtained and complications encountered were analysed with respect to certain parameters such as timing of surgery, fracture pattern (location, personality, and location), surgical experience, presence of associated injuries, method of reduction employed and the type of implant used.

Time of Surgery and time to union

Time of Surgery	Time of Union					
	Normal		Delayed		Total	
	No.	%	No.	%	No.	%
≤ 8 days	13	100	-	-	13	52
≥8 days	9	75	3	25	12	48
Total	22	88	3	12	25	100

‘p’ = 0.0957 (Not Significant)

There is no statistically significant relationship between time of surgery and time to union.

Fracture pattern and time to union

Fracture pattern	Time of Union					
	Normal		Delayed		Total	
	No.	%	No.	%	No.	%
Simple	9	90	1	10	10	40
comminuted	13	86.7	2	13.3	15	60
Total	22	88	3	12	25	100

'p' = 0.6543 (Not Significant)

Fracture pattern does not have statistically significant impact on time to union.

Fracture location and time to union

Location	Time of Union					
	Normal		Delayed		Total	
	No.	%	No.	%	No.	%
Proximal 1/3	1	100	-	-	1	4
Middle 1/3	16	94.1	1	5.9	17	68
Distal 1/3	5	71.4	2	28.6	7	28
Total	22	88	3	12	25	100

'p' = 0.1937 (Not Significant)

There is no significant relationship between fracture location and time to union.

Method of reduction and time to union

Reduction	Time of Union					
	Normal		Delayed		Total	
	No.	%	No.	%	No.	%
Closed	21	100	-	-	21	84
Open	1	25	3	75	4	16
Total	22	88	3	12	25	100

‘p’ = 0.0017 (Significant)

Statistically significant relationship exists between method of reduction and time to union.

Time to union was significantly affected by the method of reduction employed. Patients undergoing open reduction had more incidence of delayed union. **Delayed surgery and fracture pattern does not appear to have a statistically significant effect.**

FUNCTIONAL RESULTS

Time of surgery and functional results

Time of Surgery	Functional results					
	Good		Fair		Total	
	No.	%	No.	%	No.	%
≤ 8 days	13	100	-	-	13	52
> 8 days	6	50	6	50	12	48
Total	19	76	6	24	25	100

'p' = 0.0052 (Significant)

Time of surgery and functional results are significantly related.

Associated injury and functional results

Associated injury	Functional results					
	Good		Fair		Total	
	No.	%	No.	%	No.	%
Absent	16	100	-	-	16	64
Present	3	33.3	6	66.7	9	36
Total	19	76	6	24	25	100

'p' = 0.0005 (Significant)

Associated injuries significantly affect the functional results.

Delayed surgery and presence of associated injuries significantly affected the long term functional result of the patient. We believe that the effect of associated injuries is primarily due to the delay caused in surgical stabilization rather than a direct causal relationship.

ABDUCTOR WEAKNESS

Abductor weakness and implant

Implant	Abductor weakness					
	Present		Absent		Total	
	No.	%	No.	%	No.	%
Recon Nail	2	33.3	4	66.7	6	24
Sirus / PFN	-	-	19	100	19	76
Total	2	8	23	92	25	100

'p' = 0.05 (Not Significant)

Type of implant (entry portal) and the incidence of abductor weakness do not have a significant relationship.

Though one third of the patients treated with Recon nail had abductor weakness the incidence was not statistically significant.

INFECTION

Method of Reduction and Infection

Method of Reduction	Infection					
	Present		Absent		Total	
	No.	%	No.	%	No.	%
Closed	-	-	21	100	21	84
Open	3	75	1	25	4	16
Total	3	12	22	88	25	100

'p' = 0.0017 (Significant)

Method of reduction has a statistically significant relationship with the incidence of infection.

Type of Fracture and Infection

Type of Fracture	Infection					
	Present		Absent		Total	
	No.	%	No.	%	No.	%
Closed	-	-	18	100	18	72
Compound	3	42.9	4	57.1	7	28
Total	3	12	22	88	25	100

'p' = 0.0152 (Significant)

The relationship between type of fracture and infection is statistically significant.

Rate of infection was significantly higher in patients undergoing open reduction and patients who have a open wound at the site of the fracture.

SURGICAL EXPERIENCE

Operating time

	Operating time (in minutes)	
	Mean	**S.D**
Initial 13 cases	**101.46**	**7.8**
Last 12 cases	**85.67**	**10.99**
Total	**93.88**	**12.28**

‘p’ = 0.0006 (Significant)

Use of Fluoroscopy

	Fluoroscopy (in seconds)	
	Mean	**S.D**
Initial 13 cases	**85.85**	**18.98**
Last 12 cases	**55.75**	**3.97**
Total	**71.14**	**20.54**

‘p’ = 0.0001 (Significant)

The influence of surgical experience on the results obtained was analysed using operating time and the use of fluoroscopy with patients divided into two groups (initial 13 cases and the last 12 cases). **We found that the operating time and fluoroscopy use significantly improved in the later part of the study**.

STATISTICAL TOOLS

Computer analysis of data was done utilizing the software-Epidemiological Information Package 2005 (Epi info 2002) developed by the centers for disease control and Prevention – Atlanta for World Health Organization.

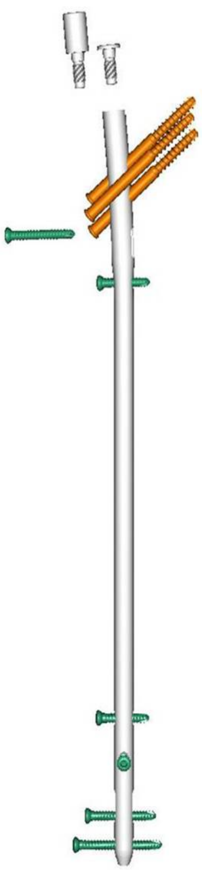
Mean, standard deviation and ‘p’ values were calculated using this package.

DISCUSSION

Complex femoral fractures continue to be problematic for the treating surgeon and the patient. There is no doubt that these fractures are best managed by surgical stabilization. Early stabilization of long-bone fractures followed by early mobilization has been shown to decrease morbidity and mortality, especially in polytrauma patients[16]. However controversies still remain regarding the most appropriate internal fixation device and which fracture should be given surgical priority. Several investigators recommend immediate reduction and stabilization of the femoral neck fracture, as an orthopedic emergency because of serious potential consequences of femoral neck fractures such as avascular necrosis, nonunion, and secondary displacement [6]. However, a delay in fixation of days to weeks does not seem to increase the complication rate [7,32].

Controversy also exists as to which internal fixation device to use for stabilization of the shaft fractures. The key for union is to obtain stable fixation regardless of the type of fixation technique used. Avoiding possible complications of plate fixation like a large surgical dissection and significant soft-tissue trauma, considerable blood loss, potentially higher infection risk, refracture, and implant failure; cephalomedullary nailing seems to be a logical option to stabilize these fractures [20, 24].

The third generation cephalomedullary nails have an inbuilt anteversion of 10° to enable neck screw placement. They have an anatomical design with a proximal mediolateral bend. The SIRUS nail and its analogues have multiple locking options which can reduce the stress on the neck screws making them an ideal device for these complex fractures.



Single device
Closed technique
Inbuilt anteversion
Multiple locking options
Anatomical design

<u>The advantages of cephalomedullary nails[6,10]</u>:

1) Single device	2) minimal collapse
3) Single incision	4) ↓ shortening, varus
5) Closed technique	6) minimal cut out rate
7) Less infection, blood loss	8) biomechanically superior

Bose et al, 1992

Friedman and Wyman, 1998

In a biomechanical analysis, Recon nail was found to be superior to multiple cancellous screws fixation for neck fractures[25].

RamserJ, Mihalko etal, 1993

<u>REVIEWING THE LITERATURE</u>:

The average blood loss in our series treated by cephalomedullary nailing was 172 ml. The results in various studies are

Average Blood loss	Wu et al 2006	Bennet et al 1993	Bose at al 1992	Our series
	300 ml	150 ml	128 ml	172 ml

<u>The average operating time in our series was 93.88 minutes.</u>

Though our initial operating time was on a higher range because of our learning curve, our results were comparable to the international studies.

Average operating time	Leung et al 1991	Wiss et al 1992	Wu et al 2006	Our series
	125 min	115 min	250 min	93.88 min

<u>Fluoroscopic exposures in our series was 71.4 sec</u>

Following is a comparison of image intensifier usage between various series

Fluroscopy	Leung et al 1991	Wiss et al 1992	Young et al	Our series
	55.7 sec	51 sec	65 sec	71.4 sec

We achieved **100% union in our series**. Except for three cases of delayed union in shaft fractures there were no incidences of non union.

Union in other series:

Union	Randelli et al (27 patients)	Maini et al (23 patients)	Hossam et al (9 patients)	Our series (25 patients)
Neck	100%union 15.1 weeks	95.7%union 15 weeks	100%union 16.7 weeks	100% union 16.28 weeks
Shaft	100%union 19.4 weeks	100%union 22 weeks	89% union 27.8 weeks	100% union 20.6 weeks

The incidence of AVN varies from 9% to 35% in various studies in these combination injuries. Various studies have concluded that delay in surgical fixation in this type of injuries had no influence on the occurrence of AVN. They have also found that AVN can occur even after 10 years in this type of injuries. We had no cases of AVN at 18 months follow up but their long term outcome is not known

AVN	Zinar et al 1993	Wiss et al 1992	Wolinsky et al 1995	Our series
	3 (7.2%)	1 (3.03 %)	2 (3.3%)	nil

Antegrade or Retrograde nailing[26]?

Retrograde nailing:

2 incisions

Biomechanically inferior

Rec. knee effusions

Advantages:

Better control over neck#

Short learning curve

Better when CR of neck# fails

(Ricci & Bellabarba, 1999)

CONCLUSION

In conclusion, a locked intramedullary nail with two proximal screws in the femoral neck and one or two distal locking screws seem useful for extended indications in complex femoral fractures, wherein previous techniques have not yielded uniformly good results.

We recommend that the surgical stabilization of these complex fractures should be done early. Though the union rate was not affected by the timing of surgery, patients undergoing early surgery had significantly better long term functional results.

The learning curve associated with cephalomedullary nailing may be long and results improve with surgical experience as shown by our study.

Though the II generation nails with piriformis fossa entry seam to have increased incidence of abductor weakness the difference is not statistically significant.

To summarize,

- Early surgical stabilization yields better long term results
- Results improve with surgical experience
- Entry portal has no influence on abductor weakness

The limitations of our study were the small sample size and the duration of follow up. Hence the power of the study is quite low to draw hardcore conclusions.

We would suggest cephalomedullary nails are effective for shaft fractures with undisplaced or displaced fractures of the femoral neck. We also suggest using third generation nails [SIRUS, long PFN] for stabilizing these fractures; SIRUS nail with its multiple locking options is the implant of choice in these complex fractures. In case of displaced neck fractures retrograde nailing with cancellous screw fixation of the neck appears promising and long term results are awaited. Cephalomedullary nailing in this complex fracture yields good results if the technique is meticulously implemented.

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PROFORMA

NAME: **D.O.A**
AGE/SEX: **D.O.S**
ADDRESS: **D.O.D**

MODE OF INJURY:

PLAIN X RAY FINDINGS:

	AO TYPE	LOCATION	DISPLACEMENT
NECK #			

	AO TYPE	LOCATION	COMMINUTION	OPEN
SHAFT #				

PRE OP PLANNING:

Estimated length of the nail:
Neck screw length:

TIME FOR SURGERY:

INTRA OP ASSESSMENT:

Anaesthesia:

Position:

Reduction:

Neck #

Shaft #

Implant:

Fixation:

Neck #:

Shaft #:

ASSOCIATED INJURIES :

OPERATING TIME:

BLOOD LOSS:

FLUROSCOPIC EXPOSURES:

INTRA OP COMPLICATIONS OR DIFFICULTIES:

POST OP PERIOD:

FOLLOW UP:

SECONDARY PROCEDURES:

TIME TO UNION:

Neck #:

Shaft #:

POST OP COMPLICATIONS:

PATIENT PROFILE

S.No.	Age	Neck		Shaft		Compound #	Implant	Complication	Functional result
		AO	D/ND	AO	C*				
1	35/M	B1.3	D	A3.2	0	C	SIRUS	-	Good
2	59/M	B2.1	ND	B2.2	1	C	SIRUS	-	Good
3	65/M	B2.1	ND	B3.2	3	C	SIRUS	Superficial infection, shortening	Good
4	48/F	B2.1	D	A2.2	0	Gr. I	RECON	Abductor weakness, delayed union	Fair (↓knee motion)
5	41/M	B2.3	D	A2.2	1	C	RECON	Distal screw breakage, abductor weakness	Fair (mild knee pain)
6	17/M	B2.1	D	B2.1	1	C	RECON	-	Good
7	28/M	B2.1	ND	B2.3	2	Gr.I	SIRUS	-	Good
8	24/M	B2.1	D	B3.2	2	Gr.II	SIRUS	-	Fair (Mild knee pain)
9	37/F	B2.1	ND	B3.3	0	C	Long PFN	Delayed union, varus malunion(N), shortening	Fair (↓knee motion)
10	38/M	B2.1	D	A3.2	0	C	SIRUS	-	Good
11	44/M	B2.1	ND	B2.2	1	C	Long PFN	-	Good
12	41/M	B2.3	D	A2.3	0	C	RECON	-	Good
13	27/M	B2.1	ND	B2.2	3	C	SIRUS	Varus malunion (N), shortening	Fair (↓knee motion)
14	42/M	B2.3	D	B2.2	1	C	RECON	-	Good
15	29/M	B2.1	D	B2.2	0	Gr.II	Long PFN	-	Good
16	26/F	B2.1	ND	A3.3	0	C	SIRUS	Deep infection	Fair (↓knee motion)
17	39/M	B2.1	ND	A3.2	2	Gr.I	SIRUS	Shortening	Good
18	32/M	B2.3	D	A3.2	0	C	RECON	Delayed union	Good
19	49/M	B2.1	ND	B3.2	1	C	Long PFN	-	Good
20	47/M	B2.1	ND	A3.3	0	Gr.II	Long PFN	-	Good
21	35/M	B2.1	D	A3.3	0	C	Long PFN	Superficial infection	Good
22	43/M	B2.3	D	B2.2	3	C	Long PFN	Shortening	Good
23	38/M	B2.1	D	B2.2	3	Gr.I	SIRUS	Shortening	Good
24	34/M	B2.1	ND	A3.3	1	C	Long PFN	-	Good
25	45/M	B2.1	D	B2.2	2	C	Long PFN	Distal screw breakage	Good

D = Displaced, ND = Undisplaced C = Closed #, Gr.I & II = Gustilo & Anderson types

C* = Comminution (Winquist & Hansen classification types)